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$$\therefore T = \frac{W(r-a+ae)}{an(1-e)}, \quad Q = \frac{W(a+ae-r)}{an(1-e)}.$$

I. For equilibrium, $T \cos \theta = Q \cos \theta + m \cos \phi$.

$$\therefore \frac{T-Q}{m} = \frac{\cos \phi}{\cos \theta} = \frac{1}{e}. \quad \therefore \frac{2W(r-a)}{amn(1-e)} = \frac{1}{e}.$$

$$\therefore r = a + \frac{amn(1-e)}{2eW} = a + \frac{an(1-e)}{2e}, \text{ when } m=W.$$

When the ring is displaced it will tend to regain this same position of equilibrium.

II. For equilibrium, $T \cos \theta = Q \cos \theta = 0$.

$\therefore r = a(1-e)$ and $r = a(1+e)$, or the upper and lower vertices. When the ring is displaced from either of these positions it will tend to equilibrium in I.

212. Proposed by W. J. GREENSTREET, M. A., Marling School, Stroud, Eng.

A peg A is vertically d feet above a peg B . A string AD , a feet long, with two equal, jointed rods DC , CB form the whole figure. Discuss the position of equilibrium.

Solution by G. B. M. ZERR, A. M., Ph. D., 4243 Girard Avenue, Philadelphia, Pa.

Let θ = the angle the string makes with the vertical; ϕ = the angle DC makes with the vertical; ψ = the angle CB makes with the vertical; b = the length of each rod; W its weight. Also regard the string as weightless, and let x = the depth of the center of gravity of the system below A .

$$\therefore x = [w(a \cos \theta + \frac{1}{2}b \cos \phi) + w(d \pm \frac{1}{2}b \cos \psi)]/2w \dots (1).$$

Projecting vertically, we get $a \cos \theta + b \cos \phi \mp b \cos \psi = d \dots (2)$.

$$\text{Also, } a^2 + d^2 - 2ad \cos \theta = 2b^2 - 2b^2 \cos(\psi - \phi) \dots (3).$$

$$a \cos \theta \text{ from (2) in (1) and (3) gives } x = [w(2d - \frac{1}{2}b \cos \phi \pm \frac{3}{2}b \cos \psi)]/2w \dots (4).$$

$$a^2 - d^2 + 2db \cos \phi \mp 2db \cos \psi = 2b^2 - 2b^2 \cos(\psi - \phi) \dots (5).$$

Differentiating (4) and (5), we get $3 \sin \psi d\psi = \pm \sin \phi d\phi \dots (6)$.

$$[b \sin(\psi - \phi) \pm d \sin \psi] d\psi = [b \sin(\psi - \phi) - d \sin \phi] d\phi \dots (7).$$

Eliminating dx and $d\phi$ between (6) and (7),

$$b \sin(\psi - \phi) (3 \sin \psi \pm \sin \phi) = 2d \sin \phi \sin \psi \dots (8).$$

(5) and (8) determine the equilibrium. The \pm sign is used as follows: if a is long enough to permit C to fall below B use the upper sign; if not, use the lower.